9-AZABICYCLO'3.3.1!NON-6-EE DERIVATIVES WITH A HETEROATOM AT THE 3-POSITION AS RENIN INHIBITORS

The invention relates to novel compounds of the general formula **I**. The invention also concerns related aspects including processes for the preparation of the compounds, pharmaceutical compositions containing one or more compounds of formula **I** and especially their use as renin inhibitors in cardiovascular events and renal insufficiency. Furthermore, these compounds can be regarded as inhibitors of other aspartyl proteases and might therefore be useful as inhibitors of plasmepsins to treat malaria and as inhibitors of *Candida albicans* secreted aspartyl proteases to treat fungal infections.

In the renin-angiotensin system (RAS) the biologically active angiotensin II (Ang II) is generated by a two-step mechanism. The highly specific enzyme renin cleaves angiotensinogen to angiotensin I (Ang I), which is then further processed to Ang II by the less specific angiotensin-converting enzyme (ACE). Ang II is known to work on at least two receptor subtypes called AT_1 and AT_2. Whereas AT_1 seems to transmit most of the known functions of Ang II, the role of AT_2 is still unknown.

Modulation of the RAS represents a major advance in the treatment of cardiovascular diseases. ACE inhibitors and AT_1 blockers have been accepted to treat hypertension (Waeber B. *et al.*, "The renin-angiotensin system: role in experimental and human hypertension", in Berkenhager W. H., Reid J. L. (eds): *Hypertension*, Amsterdam, Elsevier Science Publishing Co, **1996**, 489-519; Weber M. A., *Am. J. Hypertens.*, **1992**, *5*, 247S). In addition, ACE inhibitors are used for renal protection (Rosenberg M. E. *et al.*, *Kidney International*, **1994**, *45*, 403; Breyer J. A. *et al.*, *Kidney International*, **1994**, *45*, S156), in the prevention of congestive heart failure (Vaughan D. E. *et al.*, *Cardiovasc. Res.*, **1994**, *28*, 159;

Fouad-Tarazi F. *et al.*, *Am. J. Med.*, **1988**, *84 (Suppl. 3A)*, 83) and myocardial infarction (Pfeffer M. A. *et al.*, *N. Engl. J. Med.*, **1992**, *327*, 669).

The rationale to develop renin inhibitors is the specificity of renin (Kleinert H. D., *Cardiovasc. Drugs*, **1995**, *9*, 645). The only substrate known for renin is angiotensinogen, which can only be processed (under physiological conditions) by renin. In contrast, ACE can also cleave bradykinin besides Ang I and can be by-passed by chymase, a serine protease (Husain A., *J. Hypertens.*, **1993**, *11*, 1155). In patients inhibition of ACE thus leads to bradykinin accumulation causing cough (5-20%) and potentially life-threatening angioneurotic edema (0.1-0.2%) (Israili Z. H. *et al.*, *Annals of Internal Medicine*, **1992**, *117*, 234). Chymase is not inhibited by ACE inhibitors. Therefore, the formation of Ang II is still possible in patients treated with ACE inhibitors. Blockade of the AT_1 receptor (e.g. by losartan) on the other hand overexposes other AT-receptor subtypes to Ang II, whose concentration is dramatically increased by the blockade of AT_1 receptors. This may raise serious questions regarding the safety and efficacy profile of AT_1 receptor antagonists. In summary, renin inhibitors are not only expected to be different from ACE inhibitors and AT_1 blockers with regard to safety, but more importantly also with regard to their efficacy to block the RAS.

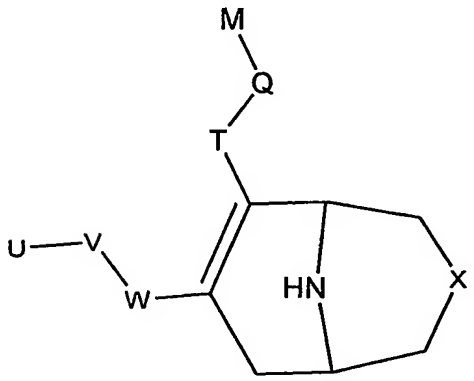
Only limited clinical experience (Azizi M. *et al.*, *J. Hypertens.*, **1994**, *12*, 419; Neutel J. M. *et al.*, *Am. Heart*, **1991**, *122*, 1094) has been created with renin inhibitors because of their insufficient oral activity due to their peptidomimetic character (Kleinert H. D., *Cardiovasc. Drugs*, **1995**, *9*, 645). The clinical development of several compounds has been stopped because of this problem together with the high cost of goods. Only one compound containing four chiral centers has entered clinical trials (Rahuel J. *et al.*, *Chem. Biol.*, **2000**, *7*, 493; Mealy N. E., *Drugs of the Future*, **2001**, *26*, 1139). Thus, metabolically stable, orally bioavailable and sufficiently soluble renin inhibitors that can be prepared on a large scale are missing and sought. Recently, the first non-peptide renin inhibitors were described which show high *in vitro* activity (Oefner C. *et al.*, *Chem. Biol.*, **1999**, *6*, 127; Patent Application WO97/09311; Märki H. P. *et al.*, *Il*

Farmaco, **2001**, *56*, 21). However, the development status of these compounds is not known.

The present invention relates to the identification of renin inhibitors of a non-peptidic nature and of low molecular weight. Orally active renin inhibitors of long duration of action which are active in indications beyond blood pressure regulation where the tissular renin-chymase system may be activated leading to pathophysiologically altered local functions such as renal, cardiac and vascular remodeling, atherosclerosis, and possibly restenosis are described.

The present invention describes non-peptidic renin inhibitors.

In particular, the present invention relates to novel compounds of the general formula **I**,



Formula **I**

wherein

X represents -O-; -S-; -SO-; -SO_2-;

W is a six-membered, non benzofused, phenyl or heteroaryl ring, substituted by V in *meta* or *para* position;

V represents a bond; -$(CH_2)_r$-; -A-$(CH_2)_s$-; -CH_2-A-$(CH_2)_t$-; -$(CH_2)_s$-A-; -$(CH_2)_2$-A-$(CH_2)_u$-; -A-$(CH_2)_v$-B-; -CH_2-CH_2-CH_2-A-CH_2-; -A-CH_2-CH_2-B-CH_2-; -CH_2-

A-CH_2-CH_2-B-; -CH_2-CH_2-CH_2-A-CH_2-CH_2-; -CH_2-CH_2-CH_2-CH_2-A-CH_2-; -A-CH_2-CH_2-B-CH_2-CH_2-; -CH_2-A-CH_2-CH_2-B-CH_2-; -CH_2-A-CH_2-CH_2-CH_2-B-; -CH_2-CH_2-A-CH_2-CH_2-B-; -O-CH_2-CH(OCH_3)-CH_2-O-; -O-CH_2-CH(CH_3)-CH_2-O-; -O-CH_2-CH(CF_3)-CH_2-O-; -O-CH_2-C(CH_3)$_2$-CH_2-O-; -O-CH_2-C(CH_3)$_2$-O-; -O-C(CH_3)$_2$-CH_2-O-; -O-CH_2-CH(CH_3)-O-; -O-CH(CH_3)-CH_2-O-; -O-CH_2-C(CH_2CH_2)-O-; or -O-C(CH_2CH_2)-CH_2-O-;

A and B independently represent -O-; -S-; -SO-; -SO_2-;

U represents aryl; heteroaryl;

T represents -$CONR^1$-; -$(CH_2)_pOCO$-; -$(CH_2)_pN(R^1)CO$-; -$(CH_2)_pN(R^1)SO_2$-; or -COO-;

Q represents lower alkylene; lower alkenylene;

M represents hydrogen; cycloalkyl; aryl; heterocyclyl; heteroaryl;

R^1 represents hydrogen; lower alkyl; lower alkenyl; lower alkinyl; cycloalkyl; aryl; cycloalkyl- lower alkyl;

p is the integer 1, 2, 3 or 4;
r is the integer 3, 4, 5, or 6;
s is the integer 2, 3, 4, or 5;
t is the integer 1, 2, 3, or 4;
u is the integer 1, 2, or 3;
v is the integer 2, 3, or 4;

and optically pure enantiomers, mixtures of enantiomers such as racemates, diastereomers, mixtures of diastereomers, diastereomeric racemates, mixtures of diastereomeric racemates, and the meso-form; as well as pharmaceutically acceptable salts, solvent complexes and morphological forms.

In the definitions of general formula I – if not otherwise stated – the term **lower alkyl**, alone or in combination with other groups, means saturated, straight and branched chain groups with one to seven carbon atoms, preferably one to four carbon atoms that can be optionally substituted by halogens. Examples of lower alkyl groups are methyl, ethyl, n-propyl, iso-propyl, n-butyl, iso-butyl, sec-butyl, tert-butyl, pentyl, hexyl and heptyl. The methyl, ethyl nad isopropyl groups are preferred.

The term **lower alkoxy** refers to a R-O group, wherein R is a lower alkyl. Examples of lower alkoxy groups are methoxy, ethoxy, propoxy, iso-propoxy, iso-butoxy, sec-butoxy and tert-butoxy.

The term **lower alkenyl**, alone or in combination with other groups, means straight and branched chain groups comprising an olefinic bond and consisting of two to seven carbon atoms, preferably two to four carbon atoms, that can be optionally substituted by halogens. Examples of lower alkenyl are vinyl, propenyl or butenyl.

The term **lower alkinyl**, alone or in combination with other groups, means straight and branched chain groups comprising a triple bond and consisting of two to seven carbon atoms, preferably two to four carbon atoms, that can be optionally substituted by halogens. Examples of lower alkinyl are ethinyl, propinyl or butinyl.

The term **lower alkylene**, alone or in combination with other groups, means straight and branched divalent chain groups with one to seven carbon atoms, preferably one to four carbon atoms, that can be optionally substituted by halogens. Examples of lower alkylene are ethylene, propylene or butylene.

The term **lower alkenylene**, alone or in combination with other groups, means straight and branched divalent chain groups comprising an olefinic bond and

consisting of two to seven carbon atoms, preferably two to four carbon atoms, that can be optionally substituted by halogens. Examples of lower alkenylene are vinylene, propenylene and butenylene.

The term **lower alkylenedioxy**, refers to a lower alkylene substituted at each end by an oxygen atom. Examples of lower alkylenedioxy groups are preferably methylenedioxy and ethylenedioxy.

The term **lower alkylenoxy** refers to a lower alkylene substituted at one end by an oxygen atom. Examples of lower alkylenoxy groups are preferably methylenoxy, ethylenoxy and propylenoxy.

The term **halogen** means fluorine, chlorine, bromine or iodine, preferably fluorine, chlorine and bromine.

The term **cycloalkyl** alone or in combination, means a saturated cyclic hydrocarbon ring system with 3 to 7 carbon atoms, e.g. cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and cycloheptyl, which can be optionally mono- or multisubstituted by lower alkyl, lower alkenyl, lower alkenylene, lower alkoxy, lower alkylenoxy, lower alkylenedioxy, hydroxy, halogen, $-CF_3$, $-NR^1R^{1'}$, $-NR^1C(O)R^{1'}$, $-NR^1S(O_2)R1'$, $-C(O)NR^1R^{1'}$, lower alkylcarbonyl, $-COOR^1$, $-SR^1$, $-SOR^1$, $-SO_2R^1$, $-SO_2NR^1R^{1'}$ whereby $R^{1'}$ represents hydrogen; lower alkyl; lower alkenyl; lower alkinyl; cycloalkyl; aryl; cycloalkyl - lower alkyl. The cyclopropyl group is a preferred group.

The term **aryl**, alone or in combination, relates to the phenyl, the naphthyl or the indanyl group, preferably the phenyl group, which can be optionally mono- or multisubstituted by lower alkyl, lower alkenyl, lower alkinyl, lower alkenylene or lower alkylene forming with the aryl ring a five- or six-membered ring, lower alkoxy, lower alkylenedioxy, lower alkylenoxy, hydroxy, hydroxy-lower alkyl, halogen, cyano, $-CF_3$, $-OCF_3$, $-NR^1R^{1'}$, $-NR^1R^{1'}$ - lower alkyl, $-NR^1C(O)R^{1'}$, $-NR_1S(O_2)R^1$, $-C(O)NR^1R^{1'}$, $-NO_2$, lower alkylcarbonyl, $-COOR^1$, $-SR^1$, $-SOR^1$,

$-SO_2R^1$, $-SO_2NR^1R^{1'}$, benzyloxy, whereby $R^{1'}$ has the meaning given above. Preferred substituents are halogen, lower alkoxy, lower alkyl, CF_3, OCF_3.

The term **aryloxy** refers to an Ar-O group, wherein Ar is an aryl. An example of a lower aryloxy group is phenoxy.

The term **heterocyclyl**, alone or in combination, means saturated or unsaturated (but not aromatic) five-, six- or seven-membered rings containing one or two nitrogen, oxygen or sulfur atoms which may be the same or different and which rings can be optionally substituted with lower alkyl, hydroxy, lower alkoxy and halogen. The nitrogen atoms, if present, can be substituted by a $-COOR^2$ group. Examples of such rings are piperidinyl, morpholinyl, thiomorpholinyl, piperazinyl, tetrahydropyranyl, dihydropyranyl, 1,4-dioxanyl, pyrrolidinyl, tetrahydrofuranyl, dihydropyrrolyl, imidazolidinyl, dihydropyrazolyl, pyrazolidinyl, dihydroquinolinyl, tetrahydroquinolinyl, tetrahydroisoquinolinyl.

The term **heteroaryl**, alone or in combination, means six-membered aromatic rings containing one to four nitrogen atoms; benzofused six-membered aromatic rings containing one to three nitrogen atoms; five-membered aromatic rings containing one oxygen, one nitrogen or one sulfur atom; benzofused five-membered aromatic rings containing one oxygen, one nitrogen or one sulfur atom; five-membered aromatic rings containing one oxygen and one nitrogen atom and benzofused derivatives thereof; five-membered aromatic rings containing a sulfur and a nitrogen or an oxygen atom and benzofused derivatives thereof; five-membered aromatic rings containing two nitrogen atoms and benzofused derivatives thereof; five-membered aromatic rings containing three nitrogen atoms and benzofused derivatives thereof, or a tetrazolyl ring. Examples of such ring systems are furanyl, thiophenyl, pyrrolyl, pyridinyl, pyrimidinyl, indolyl, quinolinyl, isoquinolinyl, imidazolyl, triazinyl, thiazinyl, thiazolyl, isothiazolyl, pyridazinyl, pyrazolyl, oxazolyl, isoxazolyl, coumarinyl, benzothiophenyl, quinazolinyl, quinoxalinyl. Such rings may be adequatly substituted with lower alkyl, lower alkenyl, lower alkinyl, lower alkylene, lower alkenylene, lower

alkylenedioxy, lower alkyleneoxy, hydroxy-lower alkyl, lower alkoxy, hydroxy, halogen, cyano, $-CF_3$, $-OCF_3$, $-NR^1R^{1'}$, $-NR^1R^{1'}$ - lower alkyl, $-N(R^1)COR^1$, $-N(R^1)SO_2R^1$, $-CONR^1R^{1'}$, $-NO_2$, lower alkylcarbonyl, $-COOR^1$, $-SR^1$, $-SOR^1$, $-SO_2R^1$, $-SO_2NR^1R^{1'}$, another aryl, another heteroaryl or another heterocyclyl and the like, whereby $R^{1'}$ has the meaning given above. Preferred heteroaryl are pyridinyl, pirimidinyl, pirazinyl.

The term **heteroaryloxy** refers to a Het-O group, wherein Het is a heteroaryl.

The expression **pharmaceutically acceptable** salts encompasses either salts with inorganic acids or organic acids like hydrochloric or hydrobromic acid, sulfuric acid, phosphoric acid, citric acid, formic acid, acetic acid, maleic acid, tartaric acid, benzoic acid, methanesulfonic acid, p-toluenesulfonic acid, and the like that are non toxic to living organisms or in case the compound of formula **I** is acidic in nature with an inorganic base like an alkali or earth alkali base, e.g. sodium hydroxide, potassium hydroxide, calcium hydroxide and the like.

Compounds of the invention also include nitrosated compounds of the general formula **I** that have been nitrosated through one or more sites such as oxygen (hydroxyl condensation), sulfur (sulffiydryl condensation) and/or nitrogen. The nitrosated compounds of the present invention can be prepared using conventional methods known to one skilled in the art. For example, known methods for nitrosating compounds are described in U.S. Pat. Nos. 5,380,758 and 5,703,073; WO 97/27749; WO 98/19672; WO 98/21193; WO 99/00361 and Oae et al, Org. Prep. Proc. Int., 15(3): 165-198 (1983), the disclosures of each of which are incorporated by reference herein in their entirety.

The compounds of the general formula **I** can contain two or more asymmetric carbon atoms and may be prepared in form of optically pure enantiomers, mixtures of enantiomers such as racemates, diastereomers, mixtures of diastereomers, diastereomeric racemates, mixtures of diastereomeric racemates, and the meso-form and pharmaceutically acceptable salts thereof.

The present invention encompasses all these forms. Mixtures may be separated in a manner known *per se*, i.e. by column chromatography, thin layer chromatography, HPLC or crystallization.

A group of preferred compounds of general formula **I** above are those wherein X, W, V, and U are as defined in general formula **I** and

T is $-CONR^1-$;
Q is methylene;
M is aryl; or heteroaryl.

Another group of even more preferred compounds of general formula **I** are those wherein X, W, U, T, Q, and M are as defined in general formula **I** above and

V is $-CH_2CH_2O-$; $-CH_2CH_2CH_2O-$; $-OCH_2CH_2O-$.

Another group of also more preferred compounds of general formula **I** are those wherein V, U, T, Q, and M are as defined in general formula **I** above and

W represents a 1,4-disubstituted phenyl group.

Another group of also more preferred compounds of general formula **I** are those wherein X, W, V, U, T, Q, and M are as defined in general formula **I** above and

U is a mono-, di-, or trisubstituted phenyl or heteroaryl, wherein the substituents are halogen, lower alkyl, lower alkoxy, CF_3.

Especially preferred compounds of general formula **I** are those selected from the group consisting of:

(*rac.*)-(*1R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(3-methoxy-2-methyl-benzyl)amide,

(*rac.*)-(*1R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(2,3-dichlorobenzyl)amide,

(*rac.*)-(*1R**, *3R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxo-3λ^4-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(3-methoxy-2-methylbenzyl)amide,

(*rac.*)-(*1R**, *3R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxo-3λ^4-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(2-methoxy-3-methylpyridin-4-ylmethyl)amide,

(*rac.*)-(*1R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-[2-(3-hydroxy-propoxy)-3-methylpyridin-4-ylmethyl]amide, and

(*rac.*)-(*1R**, *5S**)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-[2-(3-hydroxypropoxy)-3-methylpyridin-4-ylmethyl]amide.

The compounds of general formula **I** and their pharmaceutically acceptable salts may be used as therapeutics e.g. in form of pharmaceutical compositions. These pharmaceutical compositions containing at least one compound of general formula **I** and usual carrier materials and adjuvants may especially be used for the treatment or prophylaxis of disorders which are associated with a dysregulation of the renin angiotensin system (RAS), comprising cardiovascular and renal diseases. Examples of such diseases are hypertension, coronary diseases, cardiac insufficiency, renal insufficiency, renal and myocardial ischemia, and renal failure. They can also be used to prevent restenosis after balloon or stent angioplasty, to treat erectile dysfunction, glomerulonephritis, renal colic, and glaucoma. Furthermore, they can be used in the therapy and the prophylaxis of

diabetic complications, complications of vascular or cardiac surgery or after organ transplantation, complications of cyclosporin treatment, as well as other diseases presently known to be related to the RAS.

In another embodiment, the invention relates to a method for the treatment and/or prophylaxis of diseases which are related to the RAS comprising hypertension, congestive heart failure, pulmonary hypertension, cardiac insufficiency, renal insufficiency, renal or myocardial ischemia, atherosclerosis, renal failure, erectile dysfunction, glomerulonephritis, renal colic, glaucoma, diabetic complications, complications after vascular or cardiac surgery, restenosis, complications of treatment with immunosuppressive agents after organ transplantation, and other diseases which are related to the RAS, which method comprises administering a compound according to general formula **I** to a human being or animal.

The invention further relates to the use of compounds of general formula **I** for the treatment or prophylaxis of diseases which are associated with the RAS comprising hypertension, congestive heart failure, pulmonary hypertension, cardiac insufficiency, renal insufficiency, renal or myocardial ischemia, atherosclerosis, renal failure, erectile dysfunction, glomerulonephritis, renal colic, glaucoma, diabetic complications, complications after vascular or cardiac surgery, restenosis, complications of treatment with immunosuppressive agents after organ transplantation, and other diseases known to be related to the RAS.

The compounds of formula **I** may also be used in combination with one or more other pharmacologically active compounds e. g. with other renin inhibitors, with ACE-inhibitors, angiotensin II receptor antagonists, endothelin receptor antagonists, vasodilators, calcium antagonists, potassium activators, diuretics, sympatholitics, beta-adrenergic antagonists, alpha-adrenergic antagonists, and neutral endopeptidase inhibitors, for the treatment of disorders as above-mentioned

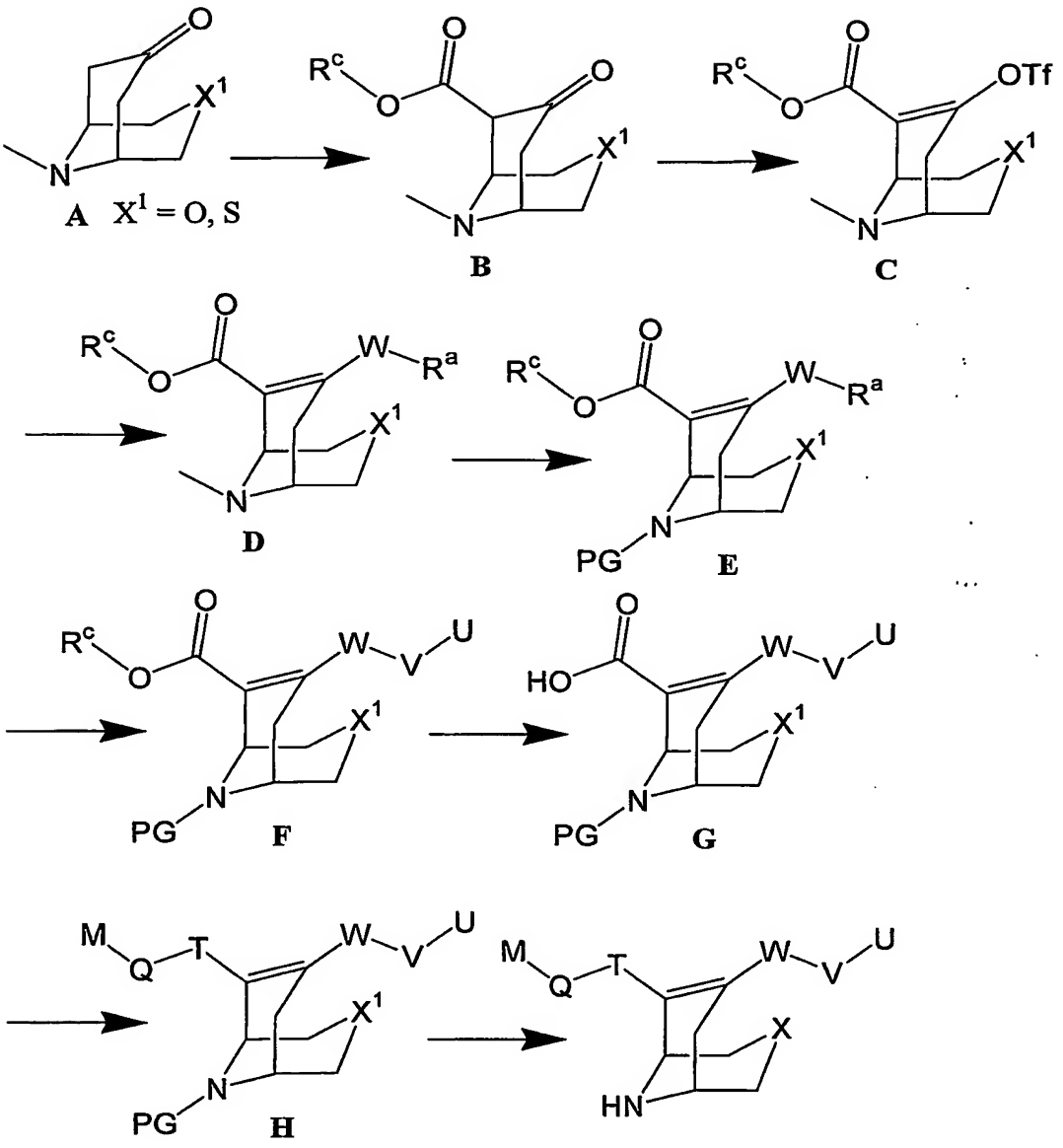
All forms of prodrugs leading to an active component comprised by general formula **I** above are included in the present invention.

The compounds of general formula **I** can be manufactured by the methods outlined below, by the methods described in the examples or by analogous methods.

Chemistry

Bicyclic sytems of type **A** (Scheme 1; Jerchel, D; *et al.*; *Justus Liebigs Ann. Chem.*, **1957**, *607*, 126; Zirkle, C. L.; *et al.*; *J. Org. Chem.*, **1961**, *26*, 395) can be used as starting material. A stereoselective or a racemic acylation (Majewski, M; *et al.*; *J. Org. Chem.*, **1995**, *60*, 5825) may yield a bicyclic compound of type **B**. R^c can typically be a methyl, an ethyl, or a benzyl substituent. These compounds can be then converted into the corresponding vinyl triflates **C**, then a carbon-carbon coupling, typically catalyzed by a Pd-complex, can lead to a derivative of type **D**. R^a optionally represents any chemical precursor of a U-V group as defined in general formula **I**. Protecting group manipulation can lead to a bicyclic system of type **E**, and standard manipulations, like deprotection and *Mitsunobu* coupling, can lead to bicyclic compounds of type **F**. Hydrolysis of the ester can lead to compounds of type **G**, then an amide coupling for instance to bicyclic compounds of type **H**. If X^1 is a sulfur atom, it can be oxidized to a sulfoxide or a sulfone at almost any stage of the process. Then deprotection can lead to the final compounds. The chemistry described in earlier patent applications, for instance in WO 03/093267 or WO 04/002957, can be used as well.

Scheme 1



The compounds of formula I and their pharmaceutically acceptable acid addition salts can be used as medicaments, e. g. in the form of pharmaceutical preparations for enteral, parenteral, or topical administration. They can be administered, for example, perorally, e. g. in the form of tablets, coated tablets, dragées, hard and soft gelatine capsules, solutions, emulsions or suspensions, rectally, e. g. in the

form of suppositories, parenterally, e. g. in the form of injection solutions or infusion solutions, or topically, e. g. in the form of ointments, creams or oils.

The production of pharmaceutical preparations can be effected in a manner which will be familiar to any person skilled in the art by bringing the described compounds of formula I and their pharmaceutically acceptable acid addition salts, optionally in combination with other therapeutically valuable substances, into a galenical administration form together with suitable, non-toxic, inert, therapeutically compatible solid or liquid carrier materials and, if desired, usual pharmaceutical adjuvants.

Suitable carrier materials are not only inorganic carrier materials, but also organic carrier materials. Thus, for example, lactose, corn starch or derivatives thereof, talc, stearic acid or its salts can be used as carrier materials for tablets, coated tablets, dragées and hard gelatine capsules. Suitable carrier materials for soft gelatine capsules are, for example, vegetable oils, waxes, fats and semi-solid and liquid polyols (depending on the nature of the active ingredient no carriers are, however, required in the case of soft gelatine capsules). Suitable carrier materials for the production of solutions and syrups are, for example, water, polyols, sucrose, invert sugar and the like. Suitable carrier materials for injections are, for example, water, alcohols, polyols, glycerols and vegetable oils. Suitable carrier materials for suppositories are, for example, natural or hardened oils, waxes, fats and semi-liquid or liquid polyols. Suitable carrier materials for topical preparations are glycerides, semi-synthetic and synthetic glycerides, hydrogenated oils, liquid waxes, liquid paraffins, liquid fatty alcohols, sterols, polyethylene glycols and cellulose derivatives.

Usual stabilizers, preservatives, wetting and emulsifying agents, consistency-improving agents, flavour-improving agents, salts for varying the osmotic pressure, buffer substances, solubilizers, colorants and masking agents and antioxidants come into consideration as pharmaceutical adjuvants.

The dosage of compounds of formula **I** can vary within wide limits depending on the disease to be controlled, the age and the individual condition of the patient and the mode of administration, and will, of course, be fitted to the individual requirements in each particular case. For adult patients a daily dosage of about 1 mg to about 1000 mg, especially about 50 mg to about 500 mg, comes into consideration.

The pharmaceutical preparations conveniently contain about 1 - 500 mg, preferably 5 - 200 mg of a compound of formula **I**.

The following examples serve to illustrate the present invention in more detail. They are, however, not intended to limit its scope in any manner.

Examples

Abbreviations

ACE	Angiotensin Converting Enzyme
Ang	Angiotensin
aq.	aqueous
Boc	*tert*-Butyloxycarbonyl
BSA	Bovine serum albumine
BuLi	*n*-Butyllithium
DIPEA	Diisopropylethylamine
DMAP	4-*N,N*-Dimethylaminopyridine
DMSO	Dimethylsulfoxide
EDC·HCl	Ethyl-*N,N*-dimethylaminopropylcarbodiimide hydrochloride
EIA	Enzyme immunoassay
Et	Ethyl
EtOAc	Ethyl acetate
FC	Flash Chromatography
HOBt	Hydroxybenzotriazol

LDA	Lithium diisopropyl amide
MCPBA	*meta*-Chloroperbenzoic acid
MeOH	Methanol
org.	organic
PG	protecting group
Ph	Phenyl
RAS	Renin Angiotensin System
RP18	Reversed phase column, filled with C_{18} hydrocarbon
rt	room temperature
sol.	Solution
TBDMS	*tert*-Butyldimethylsilyl
Tf	Trifluoromethylsulfonyl
THF	Tetrahydrofuran

Preparation of cyclopropyl-(2-methoxy-3-methylpyridin-4-ylmethyl)amine

a) 2-Chloro-3,*N*-dimethyl-*N*-phenylisonicotinamide

To the sol. of 2-chloro-*N*-phenylisonicotinamide (Epsztajn, J.; Bieniek, A.; Plotka, M. W.; Suwald, K., *Tetrahedron*, **1989**, *45*, 7469, 139.8 g, 601 mmol) in THF (1 L) was added at –78 °C BuLi (1.6 M in hexane, 826 mL, 1321 mmol) over 2 h, while the temperature of reaction mixture was kept below –65°C. The mixture was then stirred for 30 min. at this temperature. Methyl iodide (123 mL, 1.98 mol) was added and the mixture was stirred for 1 h at –78 °C. The mixture was allowed to warmed up slowly to 33 °C and stirred at this temperature for 30 min. Water (300 mL) was added dropwise, then aq. 10% NH_4OH (300 mL) was added, and the mixture was extracted with ether (3 x 300 mL). The combined org. phases were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification by FC yielded the product as pale yellow amorphous material (124.92 g, 80%).

b) 2-Chloro-3-methylpyridine-4-carbaldehyde

To a sol. of 2-chloro-3,*N*-dimethyl-*N*-phenylisonicotinamide (124.9 g, 479 mmol) in CH_2Cl_2 (1300 mL) was added at –78 °C DIBAL (1M in THF, 719 mL, 719

mmol) over 1 h, and the mixture was stirred then for 2 h at this temperature. DIBAL (1M in THF, 281 mL, 281 mmol) was added again, and the reaction mixture was stirred at –60 °C for 30 min. Aq. sat. potassium sodium tartrate (500 mL) was added over 30 min, the cooling bath was removed, and the mixture was stirred overnight at rt. Water was added (100 mL), the org. phase was separated, and the water phase was extracted with CH_2Cl_2 (2x100 mL). The combined org. phase were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification fy FC yielded the product (58.35 g, 78%) as pale yellow crystals.

c) (2-Chloro-3-methylpyridin-4-ylmethyl)cyclopropylamine

A mixture of 2-chloro-3-methylpyridine-4-carbaldehyde (58.35 g, 375 mmol) and cyclopropylamine (52.6 mL, 750 mmol) in MeOH (800 mL) was stirred overnight at rt. The mixture was cooled to 0 °C and $NaBH_4$ (18.4 g, 488 mmol) was added portionwise. The mixture was stirred overnight at rt. Aq. 1M NaOH (250 mL) was added and the solvents were partially removed under reduced pressure. The aq. phase was extracted with EtOAc (3x). The combined org. phases were washed with aq. sat. NaCl, dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification fy FC yielded the compound (54.56 g, 74%) as a pale yellow liquid.

d) Cyclopropyl-(2-methoxy-3-methylpyridin-4-ylmethyl)amine

A mixture of (2-chloro-3-methylpyridin-4-ylmethyl)cyclopropylamine (10.0 g, 50.8 mmol) and sodium methoxide (13.73g, 254 mmol) in dioxan (40 mL) was heated to reflux for 48 h. The reaction mixture was filtered through *Celite*, and the remaining solid was washed with ether (2x). The solvents were removed under reduced pressure. Purification by FC yielded the title compound (8.8 g, 90%) as a pale yellow liquid.

Preparation of {2-[3-(*tert*-Butyldimethylsilanyloxy)propoxy]-3-methyl-pyridin-4-ylmethyl}cyclopropylamine

To a sol. of NaH (55%, 4.97 g, 114 mmol) in toluene was added dropwise 3-(*tert*-butyldimethylsilanyloxy)propan-1-ol (20.1 g, 42.6 mmol) at 0 °C. The mixture

was stirred for 1 h at rt and (2-chloro-3-methylpyridin-4-ylmethyl)-cyclopropylamine (16.0 g, 81.3 mmol) was added. The mixture was heated to reflux overnight, and allowed to cool to rt. The solvents were removed under reduced pressure. The residue was diluted with Et_2O, and washed with water (2x). The combined aq. extracts were extracted back with Et_2O (2x). The combined org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification by FC yielded the title compound (7.56 g, 26%) as a pale yellow liquid.

Precursors

(*rac.*)-(*1R, *5S**)-9-Methyl-7-oxo-3-oxa-9-azabicyclo[3.3.1]nonane-6-carboxylic acid methyl ester (B1)**

A mixture of NaH (0.91 g, 60% in oil, 21 mmol) and dimethylcarbonate (2.18 g, 24 mmol) in cyclohexane (16 mL) was heated to 60 °C under nitrogen. 9-Methyl-7-oxo-3-oxa-9-azabicyclo[3.3.1]nonane **A1** (1.55 g, 10.0 mmol) was added, and the mixture was stirred at reflux for 2 h. The mixture was allowed to cool to rt, and ice and water were added. The phases were separated, and the org. phase was washed with water (1x). The combined aq. extracts were saturated with NH_4Cl, and extracted back with $CHCl_3$. The combined org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (1.02 g, 48%).

(*rac.*)-(*1R, *5S**)-9-Methyl-7-oxo-3-thia-9-azabicyclo[3.3.1]nonane-6-carboxylic acid methyl ester (B2)**

A sol. of LDA was prepared from diisopropylamine (5.8 mL, 41.2 mmol), BuLi (1.6 M in hexanes, 26.2 mL, 42.0 mmol) and THF (60 mL). This sol. was cooled to –78 °C and a sol. of 9-methyl-3-thia-9-azabicyclo[3.3.1]nonan-7-one **A2** (6.42 g, 37.5 mmol) in THF (70 mL) was added dropwise over 3 min. The reaction mixture was stirred for 3 h at -78 °C, then methylcyanoformat (3.87 mL, 48.9

mmol) was added. The reaction mixture was stirred for 1 h at -78 °C and a sol. of $AgNO_3$ (9.12 g, 53.7 mmol) in H_2O/THF (1:1, 70 mL) was added. After 10 min, H_2O (35 mL) and AcOH (35 mL) were added and the reaction mixture was allowed to warm to rt. Ammoniac (25% in water, 120 mL) was added. The reaction mixture was extracted with CH_2Cl_2 (2x). The combined org. extracts were dried over $MgSO_4$ and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (7.59 g, 88%).

(*rac.*)-(*1R, *5S**)-9-Methyl-7-trifluoromethanesulfonyloxy-3-oxa-9-aza-bicyclo[3.3.1]non-6-ene-6-carboxylic acid methyl ester (C1)**

A sol. of bicyclononanone **B1** (4.67 g, 21.9 mmol) in THF (100 mL) was cooled to 0 °C and NaH (about 60% in mineral oil, 1.13 g, about 26 mmol) was added. A gas evolution was observed. After 20 min, Tf_2NPh (10.0 g, 28 mmol) was added. 10 min later, the ice bath was removed. The sol. was stirred overnight, and diluted with EtOAc and washed with brine (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification by FC yielded the title compound as an oil (6.11 g, 81%).

(*rac.*)-(*1R, *5S**)-9-Methyl-7-trifluoromethanesulfonyloxy-3-thia-9-aza-bicyclo[3.3.1]non-6-ene-6-carboxylic acid methyl ester (C2)**

A sol. of bicyclononanone **B2** (550 mg, 2.40 mmol) in THF (10 mL) was cooled to 0 °C and NaH (about 60% in mineral oil, 144 mg, about 3.60 mmol) was added. A gas evolution was observed. After 20 min, Tf_2NPh (1.11 g, 3.12 mmol) was added. 10 min later, the ice bath was removed. The sol. was stirred overnight, and diluted with EtOAc and washed with brine (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification by FC yielded the title compound as an oil (667, 77%).

(*rac.*)-(*1R, *5S**)-7-{4-[3-(*tert*-Butyldimethylsilanyloxy)propyl]phenyl}-9-methyl-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid methyl ester (D1)**

A sol. of [3-(4-bromophenyl)propoxy]-*tert*-butyldimethylsilane (Kiesewetter D. O., *Tetrahedron Asymmetry*, **1993**, *4*, 2183, 9.88 g, 30.0 mmol) in THF (200 mL) was cooled to -78 °C. BuLi (1.6M in hexane, 18.7 mL, 30.0 mmol) was added. After 30 min, $ZnCl_2$ (1M in THF, 30 mL, 30 mmol, prepared from $ZnCl_2$ dried overnight at 150 °C and THF) was added. The mixture was allowed to warm up to rt. Vinyl triflate **C1** (5.87 g, 17.0 mmol) in THF (30 mL) and then $Pd(PPh_3)_4$ (390 mg, 0.34 mmol) were added. The mixture was heated TO 40 °C for 30 min and aq. 1M HCl (1 mL) was added. The mixture was diluted with EtOAc and washed with aq. 1M NaOH (1x). The org. extracts were dried over $MgSO_4$, filtered and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title product (5.87 g, 77%).

(*rac.*)-(*1R, *5S**)-7-{4-[3-(*tert*-Butyldimethylsilanyloxy)propyl]phenyl}-9-methyl-3-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid methyl ester (D2)**

A sol. of [3-(4-bromophenyl)propoxy]-*tert*-butyldimethylsilane (Kiesewetter D. O., *Tetrahedron Asymmetry*, **1993**, *4*, 2183, 1.52 g, 4.61 mmol) in THF (20 mL) was cooled to -78 °C. BuLi (1.6M in hexane, 2.88 mL, 4.61 mmol) was added. After 30 min, $ZnCl_2$ (1M in THF, 5.00 mL, 5.00 mmol, prepared from $ZnCl_2$ dried overnight at 150 °C and THF) was added. The mixture was allowed to warm up to rt. Vinyl triflate **C2** (667 mg, 1.85 mmol) in THF (20 mL) and then $Pd(PPh_3)_4$ (107 mg, 0.093 mmol) were added. The mixture was heated to 50 °C for 30 min and aq. 1M HCl (1 mL) was added. The mixture was diluted with EtOAc and washed with aq. 1M NaOH (1x). The org. extracts were dried over $MgSO_4$, filtered and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title product (818 mg, 96%).

(*rac.*)-(*1R, *5S**)-7-[4-(3-Hydroxypropyl)phenyl]-3-oxa-9-azabicyclo[3.3.1]-non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (E1)**

1–Chloroethyl chloroformate (5.90 g, 41 mmol) was added to a sol. of bicyclononene **D1** (5.72 g, 12.8 mmol) in 1,2-dichloroethane (75 mL). The sol. was heated to reflux. After 4 h, the reaction mixture was allowed to cool to rt, and the solvents were removed under reduced pressure. The residue was diluted with MeOH (50 mL), and the mixture was stirred for 20 min at rt, then for 45 min at 80 °C. The solvnets were removed under reduced pressure, and the residue was diluted with $CHCl_3$. This mixture was washed with aq. 1 M NaOH (1x), and brine (1x). The combined aq. extracts were extracted back with $CHCl_3$ (2x). The combined org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. The residue was dissoled in CH_2Cl_2 (60 mL), DIPEA (3.18 g, 24.6 mmol) was added, and the mixture was cooled to 0 °C. Boc_2O (3.14 g, 14.4 mmol) was added and the mixture was stirred at 0 °C for 1 h, then at rt for 2 h. The mixture was washed with aq. 1M HCl (1x), and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (4.17 g, 78%).

(*rac.*)-(*1R, *5S**)-7-[4-(3-Hydroxypropyl)phenyl]-3-thia-9-azabicyclo[3.3.1]-non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (E2)**

1–Chloroethyl chloroformate (1.93 mL, 17.7 mmol) was added to a sol. of bicyclononene **D2** (818 mg, 1.77 mmol) and $NaHCO_3$ (1.49 g, 17.7 mmol) in 1,2-dichloroethane (20 mL). The sol. was heated to reflux. After 3 h, the reaction mixture was allowed to cool to rt, filtered, and the solvents were thoroughly removed under reduced pressure. MeOH (20 mL) was added and mixture was stirred at at 60 °C for 20 min. The mixture was allowed to cool to rt and the solvents were removed under reduced pressure. The residue was dissoled in CH_2Cl_2 (20 mL), DIPEA (1.82 mL, 10.6 mmol) was added, and the mixture was cooled to 0 °C. Boc_2O (1.16 g, 5.31 mmol) was added and the mixture was stirred

at 0 °C for 30 min, then at rt for 30 min. The mixture was washed with aq. 1M HCl (1x), and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (586 mg, 76%).

(*rac.*)-(*1R, *5S**)-7-[4-(2-Hydroxyethyl)phenyl]-3,3-dioxo-3λ^6-thia-9-aza-bicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (E3)**

A sol. of compound **E2** (586 mg, 1.35 mmol) in CH_2Cl_2 (15 mL) was cooled to 0 °C and 3-chloroperbenzoic acid (70%, 359 mg, 2.97 mmol) was added. The mixture was stirred at rt for 2 h and 3-chloroperbenzoic acid (70%, 359 mg, 2.97 mmol) was added again. The mixture was stirred again for 2 h and was diluted with more CH_2Cl_2. The mixture was washed with aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (578 mg, 92%).

(*rac.*)-(*1R, *3R**, *5S**)-7-[4-(2-Hydroxyethyl)phenyl]-3-oxo-3λ^4-thia-9-aza-bicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (E4)**

A sol. of compound **E2** (0.82 g, 1.89 mmol) in CH_2Cl_2 (21 mL) was cooled to 0 °C and MCPBA (70%, 233 mg, 0.945 mmol) was added. The mixture was stirred at 0 °C for 15 min. MCPBA (197 mg, 0.880 mmol) was added again. The mixture was stirred for 15 min at rt, and was diluted with more CH_2Cl_2. The mixture was washed with aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (1.51 g,, 89%).

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (F1)**

Tributylphosphine (7.05 g, 30.0 mmol) was added to a sol. of bicyclononene **E2** (4.04 g, 9.7 mmol), 2-chloro-3,6-difluorophenol (2.89 g, 17.5 mmol) and azodicarboxylic dipiperidide (7.05 g, 30.0 mmol) in toluene (80 mL). The mixture was heated to reflux for 2 h and allowed to cool to rt. The solvents were removed under reduced pressure. Purification by FC yielded the title compound (4.60 g, 84%).

(*rac.*)-(*1R, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (F2)**

Tributylphosphine (85%, 1.08 mL, 3.72 mmol) was added to a sol. of bicyclononene **E3** (578 mg, 1.24 mmol), 2-chloro-3,6-difluorophenol (407 mg, 2.48 mmol) and azodicarboxylic dipiperidide (626 mg, 2.48 mmol) in toluene (10 mL). The mixture was heated to reflux for 2 h and allowed to cool to rt. The solvents were removed under reduced pressure. Purification by FC yielded the title compound (668 mg, 88%).

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester 6-methyl ester (F3)**

Tributylphosphine (85%, 3.30 mL, 11.3 mmol) was added to a sol. of bicyclononene **E4** (1.70 mg, 3.78 mmol), 2-chloro-3,6-difluorophenol (930 mg, 5.67 mmol) and azodicarboxylic dipiperidide (1.90 g, 7.26 mmol) in toluene (45 mL). The mixture was heated to reflux for 1 h and allowed to cool to rt. The solvents were removed under reduced pressure. Purification by FC yielded the title compound (1.94 g, 86%).

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester (G1)**

Bicyclononene **F1** (4.60 g, 25 mmol) was dissolved in EtOH (200 mL). Aq. 1M NaOH (200 mL) was added and the mixture was heated to 80 °C. The sol. was stirred for 5 h at 80 °C, then allowed to cool down to rt. After acidification to pH = 1-2 with aq. 1M HCl the mixture was extracted with EtOAc (3x). The combined org. extracts were dried over $MgSO_4$, filtered and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (4.50 g, quantitative).

(*rac.*)-(*1R, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester (G2)**

Bicyclononene **F2** (668 mg, 1.09 mmol) was dissolved in EtOH (7 mL). Aq. 1M NaOH (3 mL) was added and the mixture was heated to 80 °C. The sol. was stirred for 5 h at 80 °C, then allowed to cool down to rt. After acidification to pH = 1-2 with aq. 1M HCl the mixture was extracted with EtOAc (3x). The combined org. extracts were dried over $MgSO_4$, filtered and the solvents were removed under reduced pressure. The residue was used further without purification (624 mg, 96%).

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-3-oxo-3λ^4-thia-9-azabicyclo[3.3.1]non-6-ene-6,9-dicarboxylic acid 9-*tert*-butyl ester (G3)**

Bicyclononene **F3** (1.94 g, 3.25 mmol) was dissolved in EtOH (24 mL). Aq. 1M NaOH (10 mL) was added and the mixture was heated to 80 °C. The sol. was stirred for 1 h at 80 °C, then allowed to cool down to rt. After acidification to pH = 1-2 with aq. 1M HCl the mixture was extracted with EtOAc (3x). The combined org. extracts were dried over $MgSO_4$, filtered and the solvents were

removed under reduced pressure. The residue was used further without purification (1.86 g, 98%).

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-6-[cyclopropyl-(3-methoxy-2-methylbenzyl)carbamoyl]-3-oxa-9-azabicyclo-[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H1)**

A mixture of bicyclononene **G1** (360 mg, 2.0 mmol), cyclopropyl-(3-methoxy-2-methylbenzyl)amine (prepared by reductive amination from 3-methoxy-2-methylbenzaldehyde, Comins, D. L.; Brown, J. D., *J. Org. Chem.*, **1989**, *54*, 3730, and cyclopropylamine; 1.05 g, 6.00 mmol), DIPEA (1.37 mL, 8.00 mmol), DMAP (61 mg, 0.50 mmol), HOBt (149 mg, 1.10 mmol) and EDC·HCl (1.19 g, 6.00 mmol) in CH_2Cl_2 (10 mL) was stirred at rt for 3 days. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (260 mg, 55%).

(*rac.*)-(*1R, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-6-[cyclopropyl-(2,3-dichlorobenzyl)carbamoyl]-3,3-dioxo-3λ^6-thia-9-azabicyclo-[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H2)**

A mixture of bicyclononene **G2** (624 mg, 1.04 mmol), cyclopropyl-(2,3-dichlorobenzyl)amine (676 mg, 3.13 mmol), DIPEA (0.712 mL, 4.16 mmol), DMAP (32 mg, 0.25 mmol), HOBt (169 mg, 1.25 mmol) and EDC·HCl (498 mg, 2.60 mmol) in CH_2Cl_2 (10 mL) was stirred at rt overnight. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-6-[cyclopropyl-(3-methoxy-2-methylbenzyl)carbamoyl]-3-oxo-3λ^4-thia-9-aza-bicyclo-[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H3)**

A mixture of bicyclononene **G3** (150 mg, 0.257 mmol), cyclopropyl-(3-methoxy-2-methylbenzyl)amine (prepared by reductive amination from 3-methoxy-2-methylbenzaldehyde, Comins, D. L.; Brown, J. D., *J. Org. Chem.*, **1989**, *54*, 3730, and cyclopropylamine; 148 mg, 0.771 mmol), DIPEA (0.180 mL, 1.02 mmol), DMAP (8 mg, 0.06 mmol), HOBt (52 mg, 0.38 mmol) and EDC·HCl (123 mg, 0.642 mmol) in CH_2Cl_2 (10 mL) was stirred at rt for 2 days. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (183 mg, 94%).

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[2-(2-Chloro-3,6-difluorophenoxy)ethyl]phenyl}-6-[cyclopropyl-(3-methoxy-2-methylpyridin-4-ylmethyl)carbamoyl]-3-oxo-3λ^4-thia-9-aza-bicyclo-[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H4)**

A mixture of bicyclononene **G3** (150 mg, 0.257 mmol), cyclopropyl-(3-methoxy-2-methylpyridin-4-ylmetyl)amine (149 mg, 0.773 mmol), DIPEA (0.180 mL, 1.02 mmol), DMAP (8 mg, 0.06 mmol), HOBt (52 mg, 0.38 mmol) and EDC·HCl (123 mg, 0.642 mmol) in CH_2Cl_2 (10 mL) was stirred at rt for 2 days. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (180 mg, 93%).

(*rac.*)-(*1R, *3R**, *5S**)-6-({2-[3-(*tert*-Butyldimethylsilanyloxy)propoxy]-3-methylpyridin-4-ylmethyl}cyclopropylcarbamoyl)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-aza-bicyclo[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H5)**

A mixture of bicyclononene **G1** (2.05 g, 3.72 mmol), {2-[3-(*tert*-butyldimethylsilanyloxy)propoxy]-3-methyl-pyridin-4-ylmethyl}cyclopropyl-amine (1.96, 5.59 mmol), DIPEA (2.55 mL, 14.9 mmol), DMAP (114 mg, 0.93 mmol), HOBt (757 mg, 5.59 mmol) and EDC·HCl (2.51 g, 13 mmol) in CH_2Cl_2 (50 mL) was stirred at rt overnight. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (3.00 g, 91%).

(*rac.*)-(*1R, *3R**, *5S**)-6-({2-[3-(*tert*-Butyldimethylsilanyloxy)propoxy]-3-methylpyridin-4-ylmethyl}cyclopropylcarbamoyl)-7-{4-[3-(2-chloro-3,6-difluorophenoxy)propyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-9-carboxylic acid *tert*-butyl ester (H6)**

A mixture of bicyclononene **G2** (2.23 g, 3.72 mmol), {2-[3-(*tert*-butyldimethylsilanyloxy)propoxy]-3-methyl-pyridin-4-ylmethyl}cyclopropyl-amine (1.96, 5.59 mmol), DIPEA (2.55 mL, 14.9 mmol), DMAP (114 mg, 0.93 mmol), HOBt (757 mg, 5.59 mmol) and EDC·HCl (2.51 g, 13 mmol) in CH_2Cl_2 (50 mL) was stirred at rt overnight. The mixture was diluted with more CH_2Cl_2, and washed with aq. 1M HCl (3x) and aq. sat. $NaHCO_3$ (1x). The org. extracts were dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound (2.16 g, 62%).

Examples

Example 1

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(3-methoxy-2-methylbenzyl)amide**

Bicyclononene **H1** was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2 and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Example 2

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(2,3-dichlorobenzyl)amide**

Bicyclononene **H2** was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1 h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2 and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Example 3

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxo-3λ^4-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(3-methoxy-2-methylbenzyl)amide**

Bicyclononene **H3** was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1 h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2

and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Example 4

(*rac.*)-(*1R, *3R**, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxo-3λ^4-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-(2-methoxy-3-methylpyridin-4-ylmethyl)amide**

Bicyclononene **H4** was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1 h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2 and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Example 5

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3-oxa-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-[2-(3-hydroxypropoxy)-3-methylpyridin-4-ylmethyl]amide**

Bicyclononene **H5** (2.16 g, 2.32 mmol) was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1 h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2 and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Example 6

(*rac.*)-(*1R, *5S**)-7-{4-[3-(2-Chloro-3,6-difluorophenoxy)propyl]phenyl}-3,3-dioxo-3λ^6-thia-9-azabicyclo[3.3.1]non-6-ene-6-carboxylic acid cyclopropyl-[2-(3-hydroxypropoxy)-3-methylpyridin-4-ylmethyl]amide**

Bicyclononene **H6** (2.16 g, 2.22 mmol) was diluted with CH_2Cl_2 (10 mL) and the mixture was cooled to 0 °C. HCl (4M in dioxane, 10 mL) was added and the mixture was stirred for 1 h at 0 °C, then 1 h at rt. The solvents were removed under reduced pressdure and the residue was dried under high vacuum. The residue was diluted with CH_2Cl_2 and washed with aq. 1M NaOH until the org. phase had a pH > 9. The org. extracts wer dried over $MgSO_4$, filtered, and the solvents were removed under reduced pressure. Purification of the residue by FC yielded the title compound.

Inhibition of human recombinant renin by the compounds of the invention

The enzymatic in vitro assay was performed in 384-well polypropylene plates (Nunc). The assay buffer consisted of 10 mM PBS (Gibco BRL) including 1 mM EDTA and 0.1% BSA. The incubates were composed of 50 µL per well of an enzyme mix and 2.5 µL of renin inhibitors in DMSO. The enzyme mix was premixed at 4°C and consists of the following components:

• human recombinant renin (0.16 ng/mL) • synthetic human angiotensin(1-14) (0.5 µM)

• hydroxyquinoline sulfate (1 mM)

The mixtures were then incubated at 37°C for 3 h.

To determine the enzymatic activity and its inhibition, the accumulated Ang I was detected by an enzyme immunoassay (EIA) in 384-well plates (Nunc). 5 µL of the incubates or standards were transferred to immuno plates which were previously coated with a covalent complex of Ang I and bovine serum albumin (Ang I – BSA). 75 µL of Ang I-antibodies in essaybuffer above including 0.01% Tween 20

were added and a primary incubation made at 4 °C overnight. The plates were washed 3 times with PBS including 0.01% Tween 20, and then incubated for 2 h at rt with an antirabbit-peroxidase coupled antibody (WA 934, Amersham). After washing the plates 3 times, the *peroxidase substrate* ABTS (2.2'-azino-di-(3-ethyl-benzthiazolinsulfonate), was added and the plates incubated for 60 min at room temperature. After stopping the reaction with 0.1 M citric acid pH 4.3 the plate was evaluated in a microplate reader at 405 nm. The percentage of inhibition was calculated of each concentration point and the concentration of renin inhibition was determined that inhibited the enzyme activity by 50% (IC_{50}). The IC_{50}-values of all compounds tested are below 100 nM. However selected compounds exhibit a very good bioavailibility and are metabolically more stable than prior art compounds.